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Effects of Alerts on Army Infantry Platoon Leader Decision Making and Performance

Topics: C2 Experimentation, C2 Analysis, Cognitive Domain Issues

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Effects of Alerts on Army Platoon Leader
Decision Making and Performance

ABSTRACT

Future U.S infantry capabilities, coupled with network-centric warfare concepts, will enable advancements in information distribution and display, and will provide a combat advantage. However, the distribution of large amounts of information, especially to the visual channel may result in information bottlenecks and cognitive overload. Utilizing other human senses such as audition and touch to convey information may help Soldiers manage information, thereby enhancing their performance on the battlefield. In this paper, we describe two studies focused on identifying techniques that aid information management and enhance situational awareness and decision making for operators of future Army Combat systems, specifically, the platoon leader in the infantry command and control vehicle. The first study examined the effects of unimodal alerts on platoon leader decision making and performance. The second study used redundant alerts. This paper emphasizes the background of the research, experimental design, results, and future directions.

1.0 Background

Modern combat represents a highly complex task environment that poses many significant challenges for Soldiers. For example, during a combat situation, there are a variety of sources of information that a single Soldier must attend to and comprehend, which becomes especially problematic when considering the high operational tempo, uncertainty, and stress of combat. In addition, technological advancements as well as the need to ensure that our forces are equipped for future conflicts have led the Army to invest in the development of Future Combat Systems (FCS). At the heart of FCS is the Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) system that will provide advanced communications and technologies to link Soldiers with both manned and unmanned ground and air platforms and sensors. FCS-equipped units, therefore, must deal with a large amount of battlefield information.

The information provided by the C4ISR architecture is an important factor in maintaining situational understanding on the battlefield. However, "pushing" large amounts of information to the Soldier may not enhance their situational understanding. Rather, there are certain pieces of information that are critical for Soldiers to make adequate decisions and successfully complete their mission, and therefore, should be readily available. Another consideration is how information is presented to the Soldier. Within FCS, battlefield information is digitized and conveyed to Soldiers using an array of computer displays, which relies heavily on the visual modality. Traditionally, system designers use the visual modality as the main presentation channel, and other modalities are either ignored or used insufficiently, causing confusion and increased workload (Brickman, Hettinger, & Haas, 1999). In order to address the issues associated with information displays for FCS, an Army Technology Objective (ATO) was developed. The ATO supported research focused on reducing the potential mental workload of Soldiers who often perform multiple tasks simultaneously. A review of the literature on information processing suggests that Multiple Resource Theory (MRT) may be a useful tool in designing interfaces for applications in which operators perform several tasks at the same time (Boles, 2001). The following section gives a brief discussion of MRT and how it was applied to this project.

1.1 Theoretical basis

A fundamental goal for ATO display investigations was to support Soldiers in high workload situations by reducing their workload to evenly distributed, manageable levels. Display interventions have been particularly effective in situations where operators have multiple demands for attention. MRT suggests a potential display solution: the distribution of tasks and information across various sensory modalities. MRT proposes that humans have a finite capacity for processing information (Wickens, 1991). For example, if an operator is asked to perform two concurrent tasks, the performance of one or both of the tasks may suffer because each task has fewer available resources than when each task was performed separately (Mitchell, 2000). Off-loading some of the information to other modalities can reduce dual-task interference, which should lead to more efficient processing and improve task-sharing performance (Sklar & Sarter, 1999). To a limited extent, the military domain has implemented a multi-sensory information presentation approach. For example, system designers are utilizing auditory displays, such as alerts, in addition to traditional focal visual displays (Nikolic & Sarter, 2001, Weinstein & Wickens, 1992, Bolia et al., 1999). However, an operator may encounter situations in which their visual and auditory channels are both heavily loaded. In these situations, it may be beneficial to include the tactile modality (Sklar et al., 1999). Recently, tactile displays have been used as communication systems for pilots and astronauts to aid in spatial orientation by providing directional cues (Jones & Nakamura, 2003; Gilliland & Schelgel, 1994) and as a navigational aid (van Erp, 2005; Elliott, Redden, Krausman, Carstens, & Pettitt, 2005).

1.2 Rationale

There are many challenges involved in conveying battlefield information to the Soldier in a manner that enhances his ability to manage the information and in turn, increases his situational awareness. Research cited above suggests that multi-sensory information display may be an effective technique for improving the information management and situational understanding of Soldiers. Therefore, the overall goal of this project was to use the principles outlined in MRT to guide development of displays for presenting critical information to the Soldier, specifically the platoon leader mounted in the Infantry Platoon Leader Vehicle (IPLV), thereby enhancing his decision making. Results of this project will support development of display design guidelines that will transition to FCS developers.

1.3 Project Objectives

The first objective of this project was to identify a preliminary set of critical information requirements (CIRs) for the five crew positions in the IPLV: Driver, Vehicle Commander, Platoon Leader, Robotics NCO, and Medic.

A second objective was to build a task-network model of the IPLV, which would identify periods of high mental workload experienced by crewmembers during the modeled mission. In addition, the model would indicate the modality and interface used to display current CIRs (Mitchell, Samms, Glumm, Krausman, Brelsford, and Garrett, 2004).

Finally, based on the model output and MRT, project personnel identified alternatives for offloading information to other modalities and made recommendations for simulation studies to assess the impact of the alternative modalities on platoon leader decision making and performance (Mitchell et al., 2004).

1.4 Methodology

CIRs are the pieces of information Soldiers need to make appropriate decisions and successfully complete their mission (Mitchell et al., 2004). Job analyses, questionnaires, and SME interviews were used to obtain a preliminary set of CIRs. In addition, information derived from the job analysis helped identify a set of tasks for each crew position within the IPLV.

Next, a task-network model of the IPLV using the Improved Performance Research Integration Tool (IMPRINT) was developed that simulated tasks performed by the five crewmembers in the IPLV. The purpose of the model was to identify when crewmembers experienced high mental workload. A subsequent analysis of the model data identified tasks associated with the high workload and the modalities associated with these high workload tasks (Mitchell, et al., 2004). The platoon leader was the primary focus of the analysis. Results of the IPLV model indicated that the platoon leader experienced high workload when visually scanning the tactical display, monitoring remote operations, and receiving and comprehending digital messages.

Project personnel conducted Subject Matter Expert (SME) interviews to help verify tasks and functions included in the IMPRINT model and to identify critical information associated with the high workload tasks. Several pieces of critical information were derived from the interviews including: main routes of advance, known obstacles, objectives, limits of advance, sectors of fire, friendly and enemy locations, phase lines, course of action, status and location of unmanned assets, location of support assets, casualty evacuation routes, casualty collection points, danger areas, and urban areas.

Finally, based on the results of the IMPRINT model, SME interviews, and the principles of MRT, it was determined that two simulation experiments be conducted that examine the effects of multi-sensory information presentation on platoon leader performance. More specifically, how using visual, auditory, and tactile alerts affect the platoon leader's information management and subsequent decision making. The first study examined the effects of unimodal alerts on platoon leader decision making and performance and the second study used redundant alerts. The following section describes the two simulation experiments.

2. Experiment 1

2.1 Objective

The objective was to examine the effects of visual, auditory and tactile alerts on platoon leader performance and decision making in event-based scenarios.

2.2 Method

2.2.1 Participants

Twelve infantry officers (11A), recent graduates of the Infantry Officer Advanced Course (IOAC), volunteered to participate in this study. All participants met the vision and hearing requirements outlined in the Infantry physical profile: visual acuity of 20/200, correctable to 20/20 in each eye, and a Hearing Threshold Level (HTL) for each ear not more than 25 dB at 500, 1000, and 2000 Hz with no individual level greater than 30 dB, and not over 45 dB at 4000 Hz.. Participants ranged in age from 25 to 35 years (Mean = 29.5, SD = 3.3). A coding scheme was utilized to identify the data by participant number only (i.e. Subject 1) to maintain confidentiality. All photographs taken during the course of the study were modified to ensure that participants could not be identified.

2.2.2 Apparatus

2.2.2.1 Scenarios

Three scenarios (Table 1) were developed in collaboration with SMEs to ensure realism and mission relevance. For each scenario, experienced infantry platoon leaders (PL) played the role of the PL mounted inside a vehicle and performed typical mission-related tasks such as communications, monitoring tactical information on computer displays, and command decision making. These tasks were based on SME interviews and data from an IMPRINT task network model (Mitchell et. al., 2004). Researchers played the roles of infantry company commander (CO), infantry squad leader (SL), infantry platoon sergeant (PSG), and robotics non-commissioned officer (NCO). Scripts were developed (Krausman, Elliott, & Pettitt, 2005) to direct the order of scenario events and communications. All PL actions and communications were unscripted.

Table 1. Mission scenarios and events

Scenario	Scenario events
1	Indirect fire, direct fire, danger area and, improvised explosive device (IED)
2	Direct fire, disabled ICV, danger area/chemical attack
3	Obstacle & direct fire, indirect fire chemical attack, mine field

2.2.2.2 Alerts

Visual, auditory, and tactile alerts signaled the platoon leader of incoming text messages (Table 2). When alerted of an incoming message, the platoon leader clicked the “show message” button on the communication window of the primary display to receive the content of the message. Alerts were continuous, and stopped when the participant clicked the “show message” button.

Table 2. Description of alert presentation

Alert	Description
Visual	Solid red box on bottom portion of communications console of primary display.
Auditory	Recorded sound file (“beep”) similar to an email alert. Presented to both ears at the same time via a headset.
Tactile	“Buzz” from two tactors arranged side by side in armband and secured with a Velcro strap over the BDU sleeve.

Tactile alerts were presented to the PL using the Wireless Tactile Control Unit (WTCU) developed by Dr. Lynette Jones at the Massachusetts Institute of Technology (MIT) under the Advanced Decision Architectures Collaborative Technology Alliance (ADA CTA). The tactile sensors, called tactors, are small electomechanical vibrators that use the same DC motor found in cell phones (Lockyer, 2004). A Lycra® sleeve, worn on the upper arm, encapsulated the tactors (Figure 1).

Figure 1. Wireless Tactile Control Unit and Tactors

2.3.4 Simulation platform. The M-Body AEDGE 2 (Agent-Enhanced Decision Guide Environment) simulation platform used for this study (figure 2) was developed by 21st Century Systems, Inc., under a Phase II Small Business Innovative Research (SBIR) program, sponsored by the Army Tank-Automotive and Armaments Command-Armament Research, Development, and Engineering Center (TACOM-ARDEC). The platform simulated three movement-to-contact scenarios and consisted of two interconnected workstations with 17-inch flat panel monitors and a 48-inch flat panel for three-dimensional (3-D) graphics. Each station provided users with (a) two-dimensional (2-D) and 3-D map views with grid coordinates; (b) communications via voice and text messaging; (c) visual, auditory, and tactile alerts; (d) terrain information; (e) mission-specific icons and graphics; and (f) unmanned aerial vehicle (UAV) views. Keyboard commands controlled the movement of vehicles in the simulation. Communications were sent by text messaging or voice via a headset. Alerts (visual, auditory, and tactile) signaled incoming information. A pull-down menu allowed selection of desired alert type.

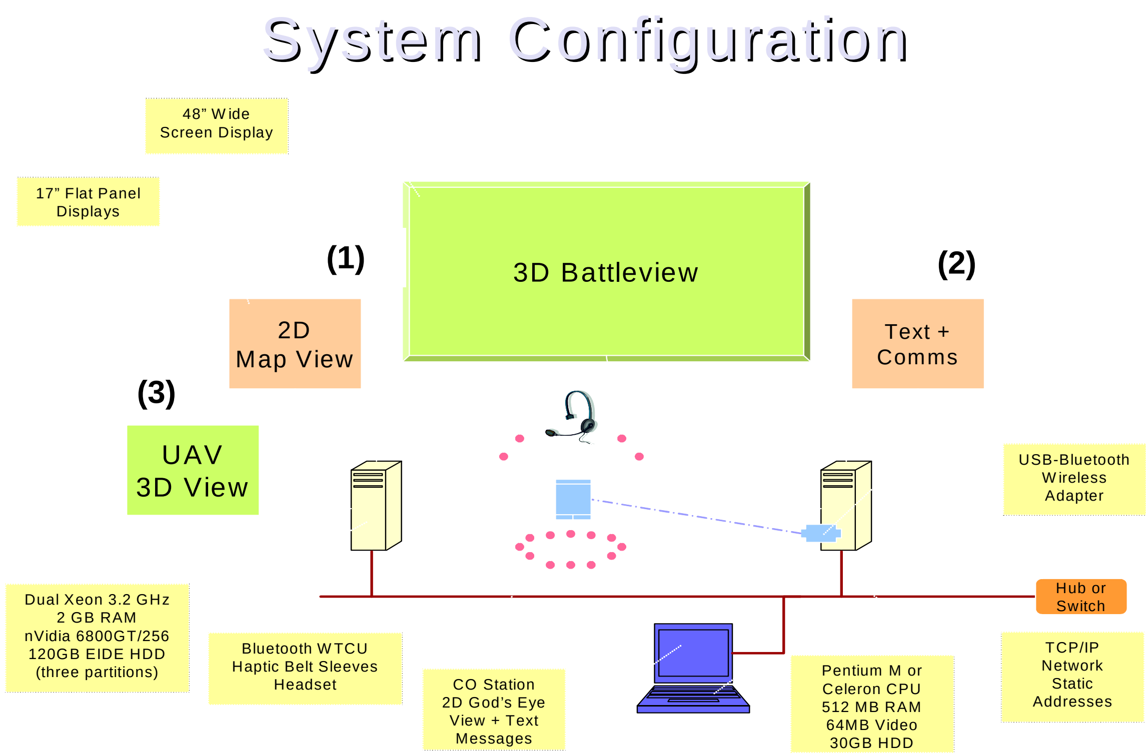


Figure 2. M-Body AEDGE® simulation platform

1. 2D Map View: displayed map graphics such as grid coordinates, line of departure, objectives, friendly and enemy positions, obstacles etc.
2. Text + Comms: displayed communications sent and received during missions. The CO and PSG sent digital messages. In order to see the contents of a digital message, the participants pressed the show message button located at the bottom of the communications display. All communication between the SL and PL were via simulated radio (verbal).
3. UAV 3D View: displayed images of the battlefield from a simulated UAV.

2.2.2.3 Questionnaires

Health and Demographics Questionnaire – Participants provided information about their current medical condition, gender, age, length of service, education level, and combat experience.

Alert evaluation – Participants rated the effectiveness, helpfulness, and necessity of the audio, tactile, and visual alerts using a Likert scale (1 = strongly agree, 5 = strongly disagree).

Alert ranking – Participants ranked the effectiveness, and helpfulness of the visual, auditory, and tactile alerts from 1 to 3 (1 = best choice, 3 = worst choice).

2.3 Experimental Design

2.3.1 Independent variable. A one-way within-subjects design was used with alert type (visual, auditory, tactile) as the independent variable. Presentation order for type of alert and scenario was counterbalanced using a balanced Latin square.

2.3.2 Dependent Variables. Response time, and the subjective alert ratings and rankings were the dependent variables. Response time was defined as the time between the participant receiving the alert and clicking the show message button on the communications display.

2.4 Procedures

Before the experiment began, participants completed an informed consent form and a health and demographic questionnaire and received a short briefing about the experimental purpose, procedures, and equipment. Each participant was assigned to the operational scenarios and read an operations order that described their mission and objectives. All three scenarios used the same OPORD. During the experiment, participants sat in front of the primary display, map display, and UAV display. During each scenario, participants received tactical communications and monitored activity on their displays. An alert (visual, auditory, or tactile) preceded some of the communications. When the platoon leader received an alert, he clicked in the communications console of his primary display to see the new message, and made a decision based on the new information. For example, if the platoon leader received a message that indicated there is a dirty area ahead, he may decide to change course and would notify his platoon. There were approximately nine alerts given for each scenario. The M-Body software recorded response time. Participants continued their mission until they reached the objective at which time they filled out the alert evaluation. Participants took a short break between scenarios. This procedure was repeated until all three scenarios were completed, which took approximately 1.5 hours. After completing all three conditions, participants filled out the alert ranking questionnaire.

2.5 Data analysis

First, an examination of the response time data indicated that the task completion time and error data did not follow a normal distribution, so a reciprocal transformation of the task completion time data was performed (Howell, 1997) and these data were analyzed using a repeated measures ANOVA (summary results are presented in original units). Alert ratings were considered as interval data and each question was analyzed with separate repeated measures ANOVAs. Frequency counts were computed for the alert ranking data. Post Hoc comparisons were made using the Tukey honestly significant difference method. Statistical tests were considered significant when $p < .05$.

2.6 Results

2.6.1 Objective data. Analysis of the response time data showed a significant main effect of alert type, $F(2, 18) = 13.69$, $p = .0002$. Post Hoc tests revealed that the mean response time for the visual alert was significantly longer than the response times for the auditory and tactile alerts (Figure 3). No significant differences were found between the auditory and tactile alert response time (p = .2146). Closer examination of the means showed a larger dispersion of response times for the visual alert, with eight of the twelve subjects having a response time of greater than 10 seconds. Only one subject had a response time of greater than ten seconds for the tactile alert, and for the auditory alert, all response times were less than ten seconds.

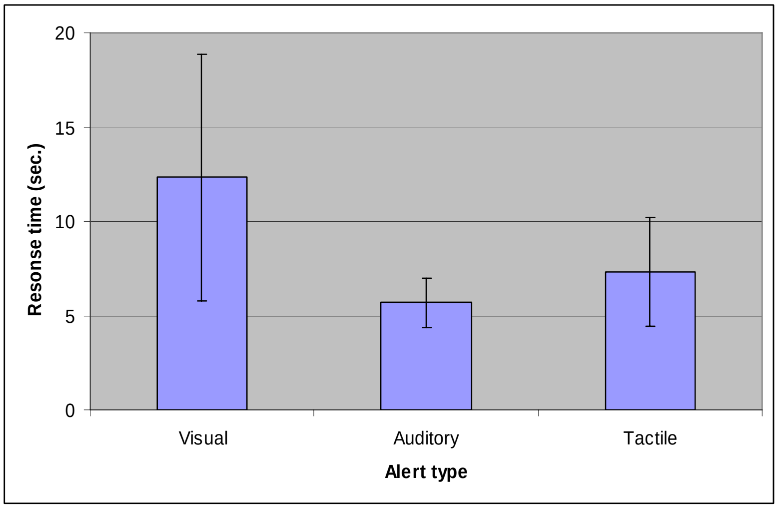


Figure 3. Mean (sd) response time for each alert type

2.6.2 Subjective data

2.6.2.1 Item 1 – Alert was effective at getting my attention

Alert type, $F(2, 22) = 16.10$, $p < .0001$, had significant effects on item 1. Mean ratings were significantly lower for the auditory and tactile alerts (Figure 4), suggesting that participants thought that the auditory and tactile alerts were more effective at getting attention than the visual alert.

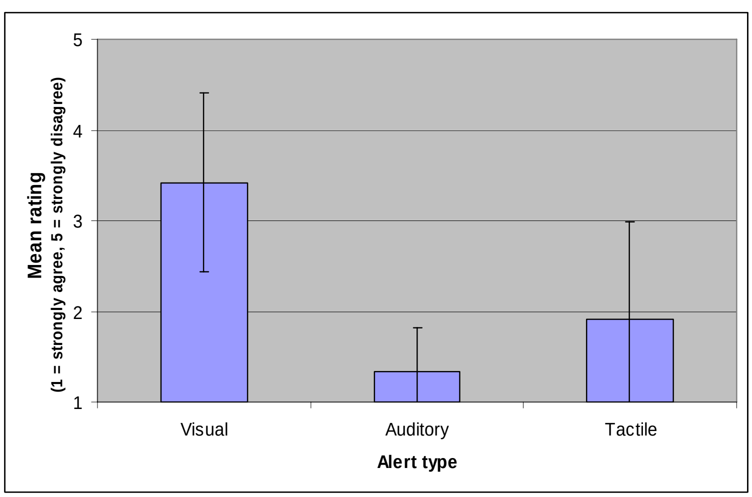


Figure 4. Mean (sd) rating for effectiveness at getting attention

2.6.2.2 Item 2 – Alert was helpful

No significant effects of alert type were found on Item 2 (*p* = .059). Mean (sd) ratings for the alert types were as follows: auditory = 1.67 (0.65), tactile = 2.25 (1.06), and visual = 2.5 (0.90).

2.6.2.3 Item 3 – Alert was annoying and unnecessary

No significant effects of alert type were found on Item 3 (*p* = .088). Mean (sd) ratings for the alert types were as follows: auditory = 3.75 (0.97), tactile = 3.58 (0.99), and visual = 3.67 (0.98).

2.6.2.4 Preference Rankings. Frequency counts helped identify the type of alert that participants considered the best, next best, and worst choice for getting their attention and helpfulness. For getting attention (Figure 5), participants chose the auditory alert as the most effective at getting their attention. The auditory and tactile alerts tied as next best choice, and the visual alert was the least effective at getting participant's attention. With respect to the helpfulness of alerts (Figure 6), the tactile alert was most helpful, followed by the auditory alert as the next best. Participants thought the visual alert was the least helpful.

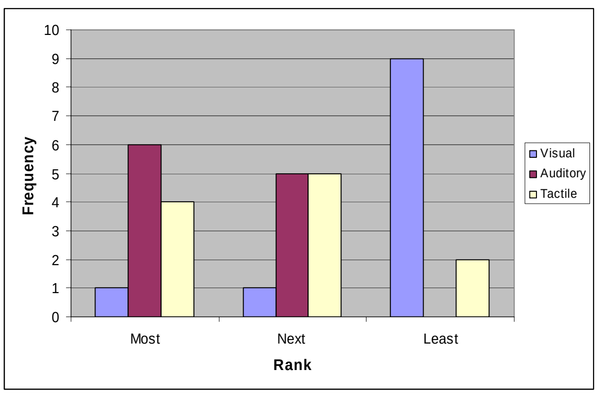


Figure 5. Frequency counts for effectiveness of alert at getting attention

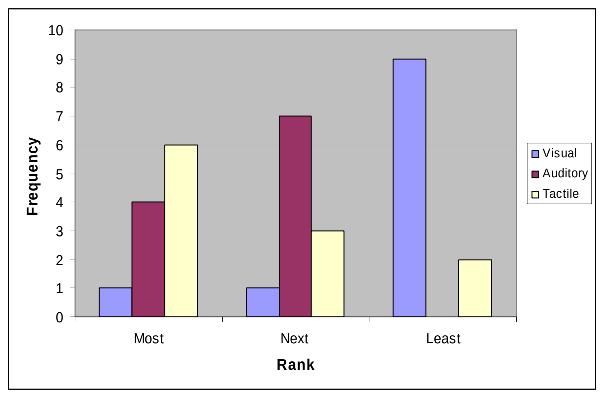


Figure 6. Frequency counts for helpfulness of alerts

2.7 Participants Comments

Participants indicated that the visual alert was not very effective at getting their attention, which corresponds to the findings of the objective data. Preference data showed that participants favored the auditory and tactile alerts because they easily got their attention, but did not interfere with concurrent tasks. Participants also noted that caution be exercised when implementing auditory and tactile alerts in combat vehicles. For example, environmental noise and the use of multiple radio nets within a vehicle may mask the auditory alert. In addition, the tactile alert may be difficult to detect in a moving vehicle due to vehicle vibration. Participants suggested that a combination of alerts might be the best option.

3. Experiment 2

3.1 Objective

The objective was to examine the effects of redundant alerts on platoon leader performance and decision making in event-based scenarios.

3.2 Method

3.2.1 Participants

Eleven infantry officers (11A), recent graduates of the Infantry Officer Advanced Course (IOAC), volunteered to participate in this study. All participants met the vision and hearing requirements outlined in the Infantry physical profile: visual acuity of 20/200, correctable to 20/20 in each eye, and an audiometer average level for each ear not more than 25 dB at 500, 1000, 2000 Hz with no individual level greater than 30 dB, and not over 45 dB at 4000 Hz. Participants ranged in age from 25 to 40 years (Mean = 29.6, SD = 4.4). The same coding scheme used in experiment 1 was used for this experiment.

3.2.2 Apparatus

3.2.2.1 Scenarios

The same scenarios, simulation platform, and questionnaires used for the first experiment were also used for this experiment.

3.2.2.2 Alerts

A single visual alert and two redundant alerts (visual + auditory, and visual + tactile) signaled the platoon leader of incoming messages (Table 2). The redundant alerts were comprised of multiple modalities presented simultaneously. When alerted of an incoming message, the platoon leader clicked the “show message” button on the communication window of the primary display to receive the content of the message. Alerts were continuous, and stopped when the participant clicked the show message button.

3.3 Experimental Design

3.3.1 Independent variable. The experimental design was a one-way within subjects design. Type of alert (visual, visual + auditory, visual + tactile) was the independent variable. Presentation order for type of alert and scenario was counterbalanced using a balanced Latin square.

3.3.2 Dependent Variables. Response time, and the subjective alert ratings and rankings were the dependent variables. Response time was defined as the time between receiving an alert and clicking the show message button on the communications display.

3.4. Procedures

The same procedures used in the first experiment were followed for this experiment.

3.5 Data analysis

The same data analysis procedures used in the first experiment were followed for this experiment.

3.6 Results

3.6.1 Objective data

Analysis of the response time data showed a significant main effect of alert type, $F(2, 16) = 14.61$, $p = .0002$. Post Hoc tests revealed that the mean response time for the visual alert was significantly longer than the response times for the visual + auditory and visual + tactile alerts (Figure 7). No significant differences were found between the visual + auditory and visual + tactile alert response time ($p = .8864$).

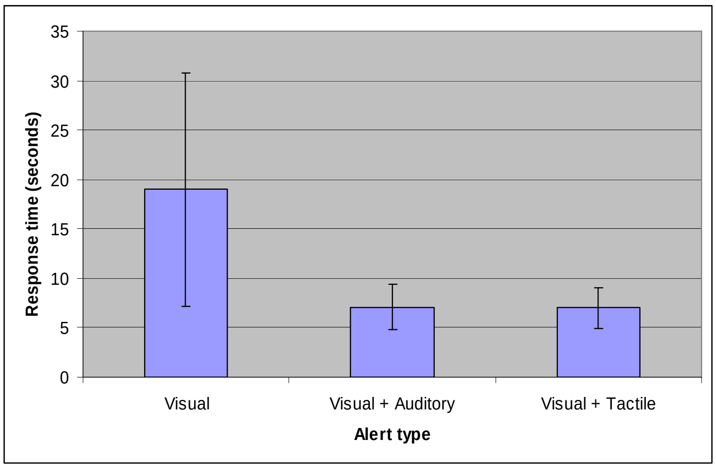


Figure 7. Mean (sd) response time for each alert type

3.6.2 Subjective data

3.6.2.1 Item 1 – Alert was effective at getting my attention

Alert type, $F(2, 20) = 11.04$, $p < .0006$, had significant effects on item 1. Mean ratings were significantly higher for the visual alert (Figure 8), suggesting that participants thought that the visual + auditory and visual + tactile alerts were more effective at getting attention than the visual alert.

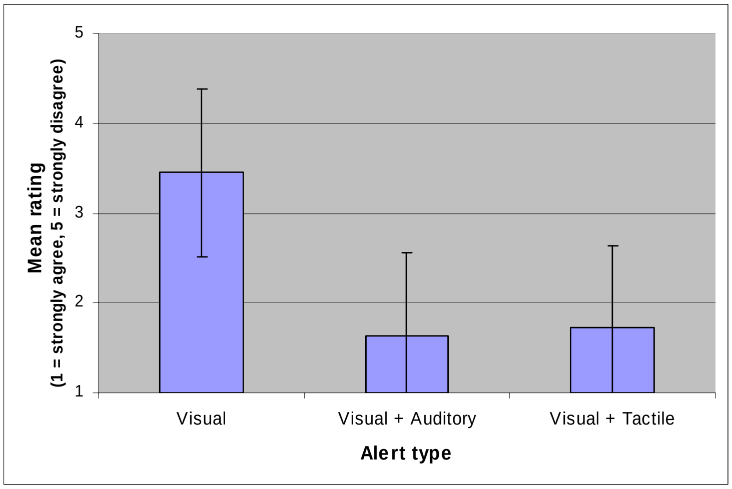


Figure 8. Mean (sd) rating for effectiveness at getting attention

3.6.2.2 Item 2 – Alert was helpful

No significant effects of alert type were found on Item 2 (p = .332). Mean (sd) ratings for the alert types were as follows: visual = 2.27 (0.90), visual + auditory = 1.73 (0.79), visual + tactile = 1.82 (0.98).

3.6.2.3 Item 3 – Alert was annoying and unnecessary

Alert type, $F(2, 20) = 4.12$, p =.0317, had significant effects on item 3. Mean ratings were significantly higher for the visual alert than the visual + auditory alert (Figure 9), suggesting that participants thought that the visual + auditory alert was slightly more annoying than the visual alert alone. No significant differences were found between the ratings for the visual and visual + tactile alerts.

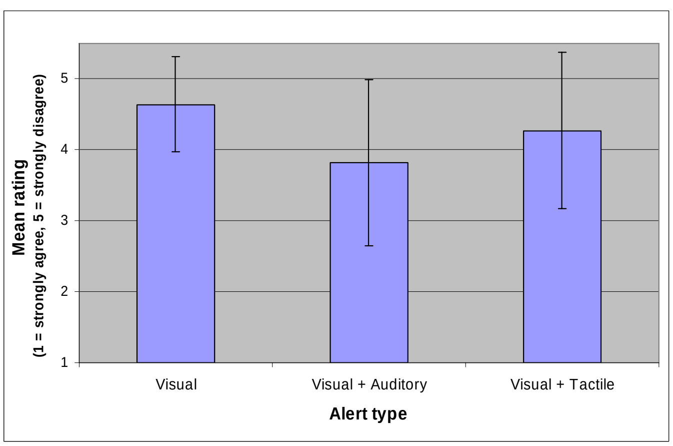
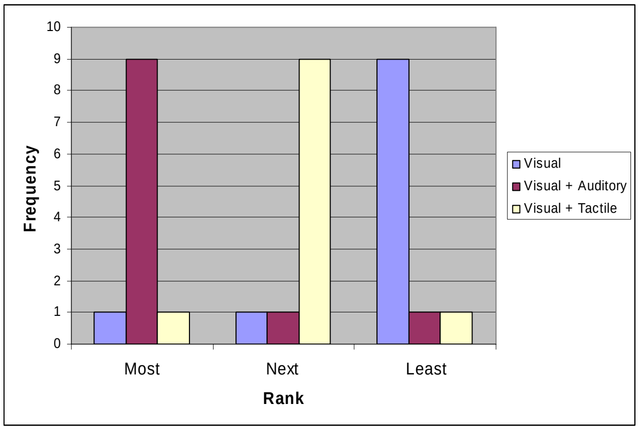


Figure 9. Mean (sd) rating for annoying

3.6.2.4 Preference Rankings

Frequency counts helped identify the type of alert that participants considered the best, next best, and worst choice for getting their attention and helpfulness. For getting attention (Figure 10), participants chose the visual + auditory alert as the most effective at getting their attention. The visual + tactile alert was selected as the next best choice, and the visual alert was the least effective at getting participant's attention. With respect to the helpfulness of alerts (Figure 11), the combined alerts (visual + auditory, visual + tactile) were selected as the most and next most helpful, and the visual alert was clearly identified as the least helpful.



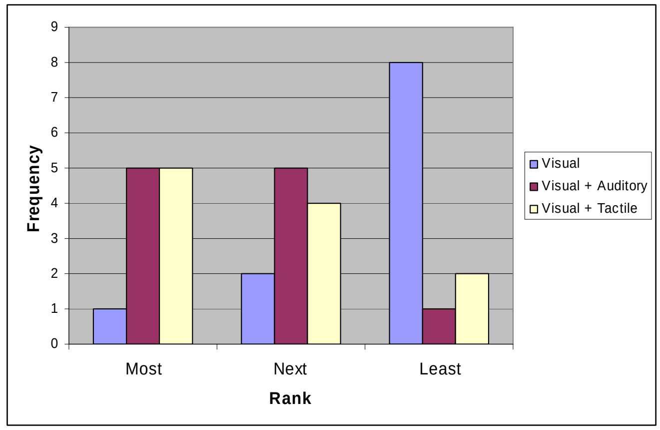


Figure 10. Frequency counts for effectiveness of alert at getting attention

Figure 11. Frequency counts for helpfulness of alerts

3.7 Participants Comments

As reflected by the objective and subjective data, participants thought the visual alert was the least effective at getting their attention, and the least helpful. Participants indicated that the visual alert required constant checking to avoid missing messages, and added that it would be impossible to conduct operations and maintain constant awareness of the visual alert. With regard to the combination alerts, participants perceived these alerts as effective because they were able to monitor multiple sources of information without focusing all of their attention on the primary display. The visual + tactile alert was considered to be less distracting than the visual + audio alert because it did not interfere with the other senses that were already engaged. As mentioned in the first study, participants stated that vehicle noise and vibration may interfere with or mask the auditory and tactile stimuli. Participants also mentioned that they thought the alerts would be more effective if information was prioritized (i.e., different sounds or patterns for routine and urgent messages).

4. Discussion.

Many challenges exist when designing interfaces that provide sensory feedback, especially when considering that many interfaces rely heavily on the visual channel, which can easily become overloaded (Hopp, Smith, Clegg, & Heggestad, 2005). As mentioned previously, the literature on information processing suggests that MRT may be a useful tool in designing interfaces for applications in which operators perform several tasks at the same time (Boles, 2001). For example, since the platoon leader's visual channel is overloaded; distributing tasks and information across other sensory modalities may help reduce overall workload (Wickens & Hollands, 2000; Sarter, Waters, & Ho, 2003). The first study used the principles of MRT to examine the effects of single alerts (visual, auditory, and tactile) on platoon leader decision making and performance. Results showed that response time for the visual alert was 54% slower than the auditory and 41% slower than the tactile alert, which was expected because the platoon leader was already engaged in visually demanding tasks, such as monitoring remote operations and scanning tactical displays. In addition, these results are consistent with other findings in the literature, which suggest that auditory and tactile alerts are effective "attention grabbers" (Helleberg & Wickens, 2001). For example, auditory cues like speech and non-speech auditory alerts or warnings can attract attention to a situation, control, or display (Laughery & Wogalter, 1997; Haas & Edworthy, 2003; Bolia, et al., 1999). Tactile displays can alert pilots of possible threats or other situations that may occur during a mission especially when the visual channel is already overloaded or unavailable (Gilliland et al., 1994).

Subjective data from the first experiment also indicated that participants preferred the auditory and tactile alerts because they easily got their attention, but did not interfere with concurrent tasks. The literature describes this type of alert as an ideal alert or interruption: one that minimally distracts ongoing task performance while providing a clear signal of another source requiring the individual's attention (Hopp et al., 2005). In addition, the auditory and tactile alerts elicited a significantly faster response time. However, implementing auditory and tactile alerts in moving combat vehicles could be problematic due to environmental noise and vibration, which would make the alerts difficult to detect. As a result, a redundant combination of display modalities may be an effective alternative to presenting information to a single modality. For example, using a combination of cues would enable a platoon leader to hear a message or alert while continuing to scan the battlefield, but would also enable him to see the information being displayed, if necessary (Helleberg et al., 2001). Redundancy can also serve as an aid for visual search and detection of changes that occur on complex visual displays (Tan, Gray, Young, & Irawan, 2001).

The concept of using redundant alerts was examined in the second experiment. Results indicated that the response time for the visual alert alone was 63% slower when compared to both the visual + auditory and visual + tactile alerts. Wickens et al. (2000) suggests that redundantly coding targets across modalities (visual warning coupled with an auditory beep) shortens response time, which was demonstrated in the present study. One potential advantage to designing redundancy into future combat systems is that in the event that vehicle noise or vibration masks the auditory or tactile portion of the alert, the operator could still rely on the visual alert.

Subjective data from the second experiment were consistent with the objective data and indicated that the redundant alerts (visual + auditory, visual + tactile) were more effective at getting the PL's attention, than the single visual alert. No differences were found for the aspect of alert helpfulness, however, the visual + auditory alert was considered more annoying than the other alerts. This was also described in the participant comments. One possible explanation is that the auditory portion of the alert made it difficult to attend to other ongoing audio communications. Perhaps building a level of prioritization into the alert (i.e. different sounds for routine and urgent messages) would reduce distraction and help the PL know where to focus his attention. Another solution may be to code additional information into the alert. For example, using an auditory earcon such as a siren would get the PLs attention, and would indicate that a chemical agent has been detected. Rank data was also consistent with other data. Participants identified the redundant alerts as the best and next best choices for effectiveness at getting attention and helpfulness, and the visual alert was identified as the worst choice.

5. Conclusions and Future Work

As mentioned previously, the overall goal of this project was to use the principles outlined in MRT to guide development of displays for presenting critical information to the platoon leader, thereby enhancing his decision making. Results of the experiments described above support the results of the IMPRINT task-network model described in the methodology section. Namely, display designs that incorporate a visual alert can lead to response times that are twice as long as using the auditory and tactile modalities, when in a visually demanding environment. When utilizing the concept of redundancy (Wickens et al., 2000), response times can be expected to be up to 63% faster than a single visual alert. These results suggest that alerts provide an effective method of information management in a visually demanding environment. In addition, using redundant alerts may ease some of the challenges associated with implementing auditory and tactile alerts in combat vehicles.

To address the challenge of implementing tactile signals in moving vehicles, future research will examine the tactile signal characteristics that enhance detectability in moving vehicles and when performing combat assault maneuvers. Other efforts will examine how coding additional information into the alerts enhances their effectiveness.

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Effects of Alerts on Army Platoon Leader Decision Making and Performance

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ICCRTS June 20, 2006

Challenge

- Modern combat ……
  - Highly complex task environment
  - Stress and uncertainty of battle
  - Operational tempo

- Distribution of large amounts of information can lead to:
  - Cognitive overload
  - Information bottlenecks

Approach

- Army Technology Objective (ATO)
  - Research centered on display designs
    - Reduce the potential workload of soldiers
    - Enhance information management and decision making

- Focus
  - Future Combat Systems (FCS)
    - Infantry Carrier Vehicle (ICV)
    - Platoon leader

Objectives

Build task network model using the Improved Performance Research Integration Tool (IMPRINT) to identify instances of high workload

↓

Identify candidate technologies and techniques for mitigation of workload peaks

↓

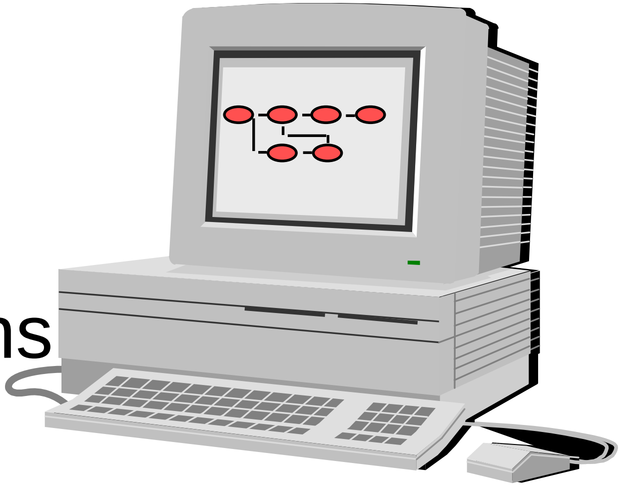
Conduct research to investigate techniques to mitigate workload and improve decision making of platoon leader

↓

Display design guidelines for FCS

IMPRINT Model

- Modeled tasks performed by five crewmembers in the IPLV
  - High mental workload
    - Tasks
    - Modalities
- PL overloaded:
  - Scanning display
  - Monitoring remote operations
  - Communications



Mitigation Techniques

- Literature states that alerts may be effective aids for information management.
  – Helleberg & Wickens, 2001
  – Laughery & Wogalter, 1997
  – Haas & Edworthy, 2003

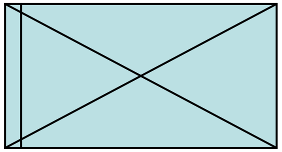
Platform Description

- M-Body AEDGE® simulation platform
  - Developed by 21st Century Systems Inc. (21csi).
    - Decision support system
  - Phase III SBIR
  - Capabilities extended to include:
    - Tactile transducers
    - Data collection

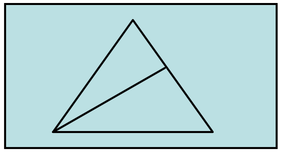
AEDGE = Agent Enabled Decision Group Environment

Platform Capabilities

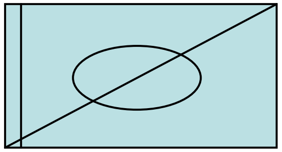
- Battlefield visualization
  - 2D & 3D maps, icons and graphics



- Dynamic scenarios
- Communications
  - Voice and digital

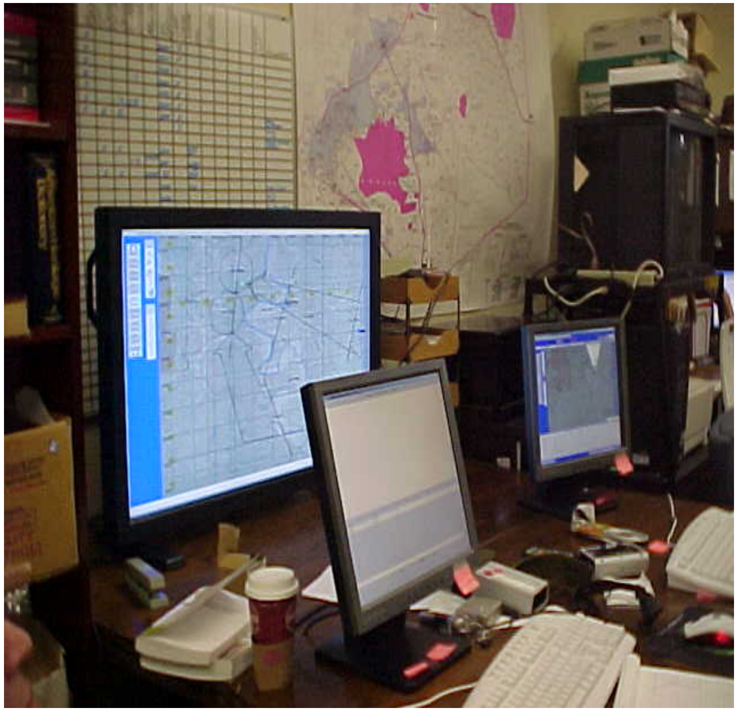


- Multi-sensory alerts
  - Visual, auditory, and tactile integration
- Data collection capability
  - Time stamps, events logged

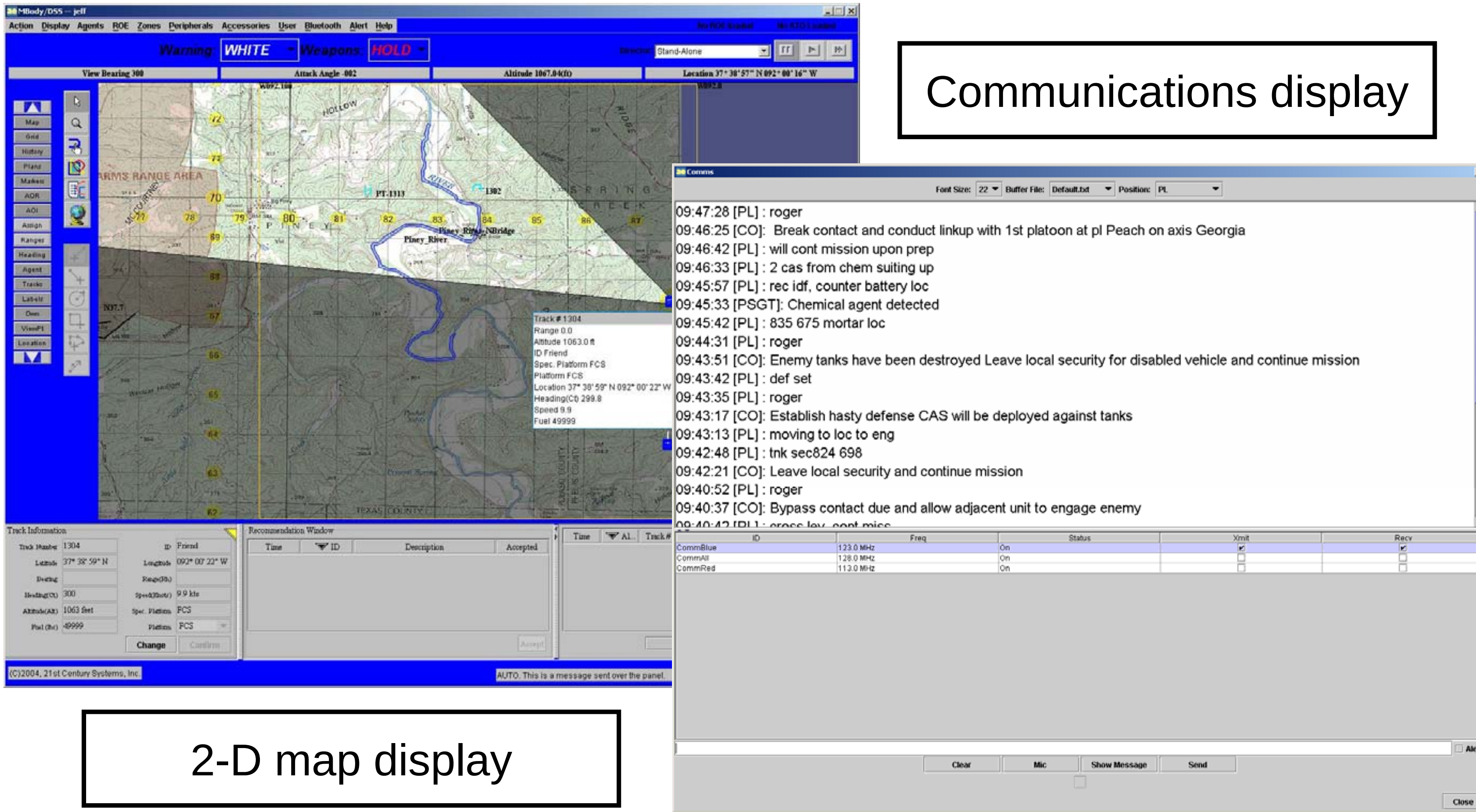


Platform Description (cont'd)

- Configuration
  - 2 interconnected workstations (client, server)
  - 2 – 17 inch flat panel displays (map & UAV views)
  - 1 – 48 inch wide screen display (map display)



Platform Description (cont'd)



Communications display

2-D map display

Platform Description (cont'd)

- Data collection
  - User-defined
    - Event type
    - Frequency
  - Separate data files generated
    - Client
    - Communications
    - Event
    - Log

Scenario Development

- Developed in collaboration with Subject Matter Experts (SMEs)
  - Mission relevance
  - Equivalent workload
    - Monitoring remote operations
    - Receiving and sending messages (digital and voice)
    - Scanning the battlefield

- Scenarios programmed into simulation

Scenario	Description
1	Indirect fire, direct fire, danger area, & improvised explosive device (IED)
2	Direct fire, disabled ICV, danger area/chemical attack
3	Obstacle & direct fire, indirect fire chemical attack, mine field

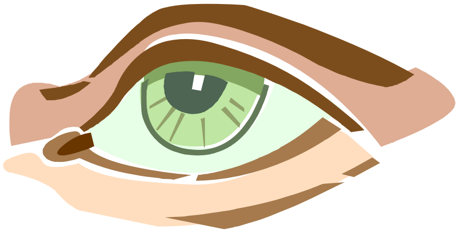
Scenario Roles

- 5 crew positions included in each scenario
  - Platoon leader
  - Company commander
  - Squad leader
  - Platoon sergeant
  - Robotics NCO
- Scripts created
  - Ensured consistency
  - Timing of alerts

SL (to PL): Roger, received FRAGO
SL (to PL): Enemy strong point destroyed
PL (to SL): acknowledges
PL (to CO): reports enemy strong point detected
SL (to PL): Enemy at 10 o'clock taking direct fire, we are engaging enemy
PSG(to PL): FM commo down and we have 2 casualties requiring evacuation.
1st SL (to PL): ICV disabled

Research

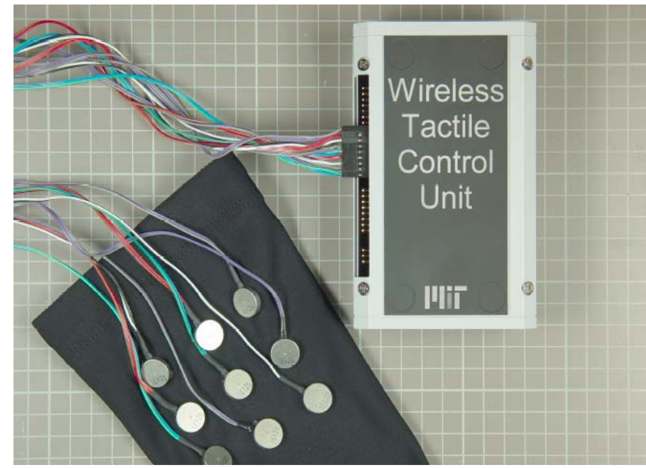
- Focus
  - To examine the effects of alerts on the decision making and performance of a platoon leader during a mounted attack mission.



- Approach
  - Two simulation experiments
    - Unimodal alerts
    - Multimodal alerts

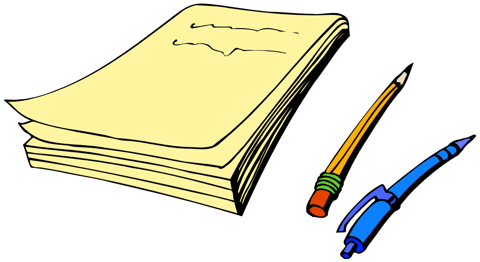
Apparatus

- Equipment
  - MBODY AEDGE platform used to simulate three scenarios.
- Alerts (signaled incoming information)
  - Visual –
  - Auditory – “beep”
  - Tactile – vibration



Apparatus (Cont'd)

- Questionnaires
  - Alert rating (Likert scale)
    - Effectiveness
    - Helpfulness
    - Annoying



☐	☐	☐	☐	☐
Strongly Agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Disagree**

  - Alert ranking (Scale 1 – 3)
    - Example: 1 = most effective, 3 = least effective

Participants

- Experiment 1: 12 infantry officers (11A)
  - Mean age: 29.5 (S.D. = 3.3)

- Experiment 2: 11 infantry officers (11A)
  - Mean age: 29.6 (S.D. = 4.4)

Experimental design

- One way within-subjects
    - IV = Alert type
        - Experiment 1: visual, auditory, tactile
        - Experiment 2: visual, visual + auditory, visual + tactile
    - DV = Response time, ratings, rankings

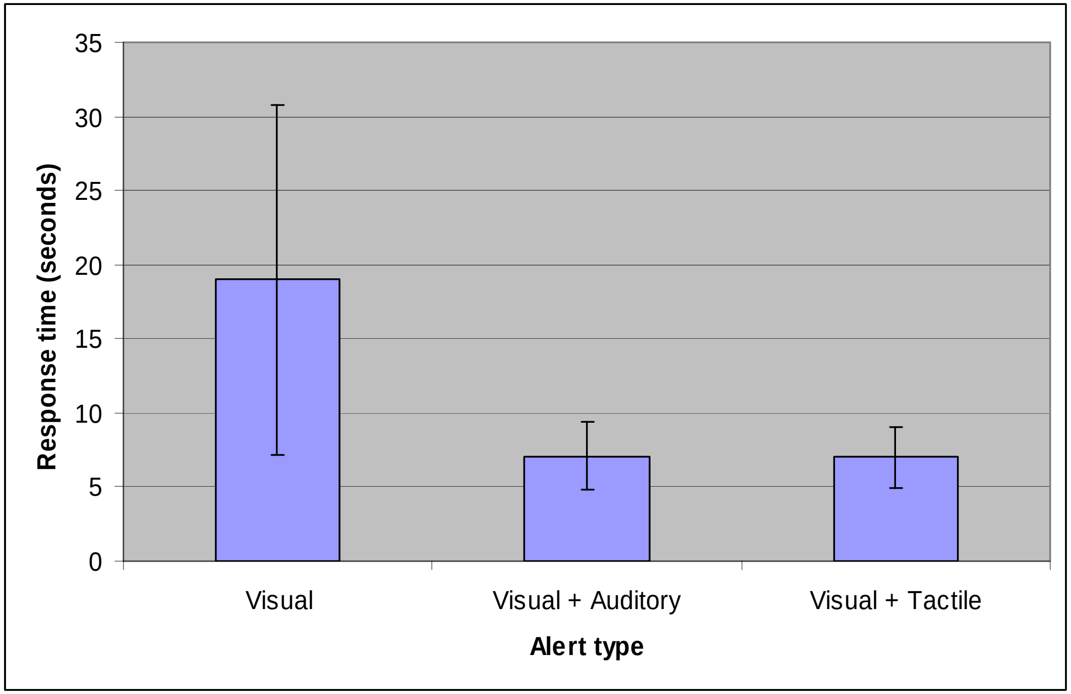
Video Highlights

Experiment 1

- Summary (2005 CCRTS Proceedings)
  - Visual alert:
    - 54% slower than auditory
    - 41% slower than tactile
  - Auditory & tactile alerts rated more helpful than visual alert
  - Visual alert ranked as worst choice for getting attention and was considered the least helpful

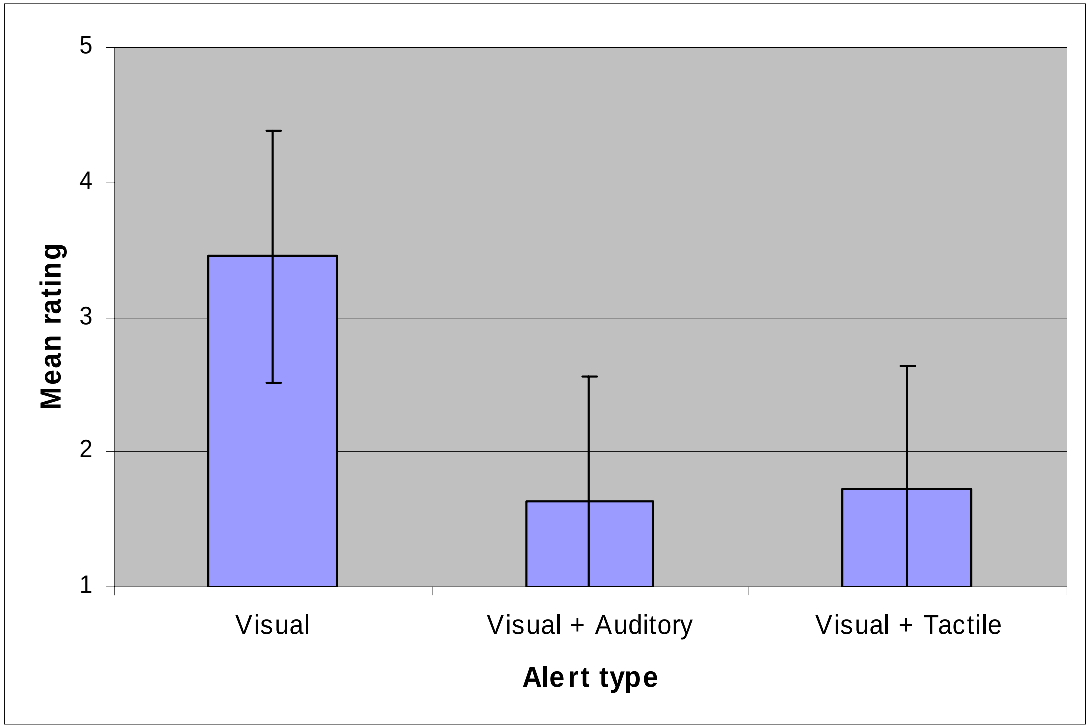
Experiment 2 - Results

- Objective data (ANOVA)
  - Main effect of alert type (p = .0002)
    - Visual alert response time significantly longer than response time for redundant alerts.



Experiment 2 - Results

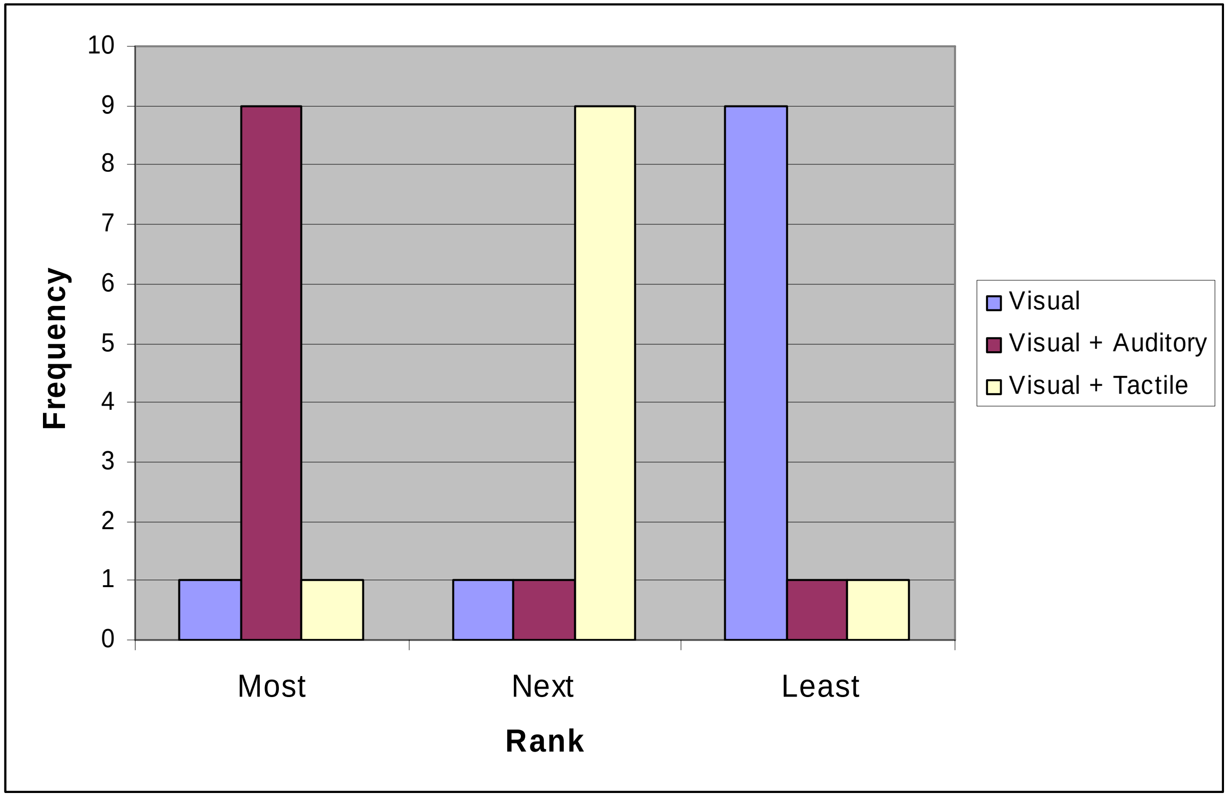
- Subjective ratings (ANOVA)
  - Alert type had significant effects on getting attention ($p < .0006$)
    - Auditory & Tactile alerts rated more effective than visual alert



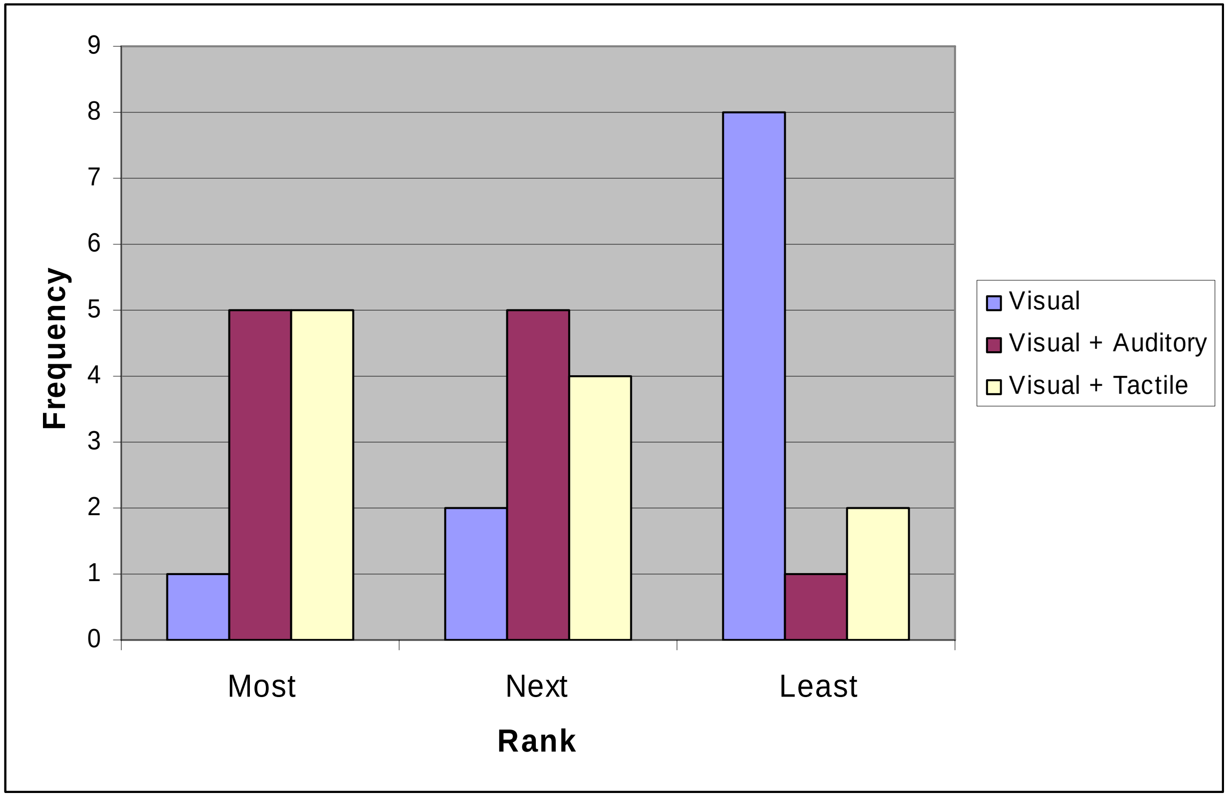
Experiment 2 - Results

- Subjective rankings (Frequency count)
  - Getting attention
    - Most effective = visual + auditory
    - Second most effective = visual + tactile
    - Least effective = visual
  - Helpfulness
    - Most helpful = visual + auditory/visual + tactile
    - Second most helpful = visual + auditory
    - Least helpful = visual

Getting attention



Helpfulness



Conclusions

- Redundant alerts may enable platoon leader to better manage information than single alerts, thereby impacting decision making.
  - Limitations
    - Environmental noise
    - Vehicle vibration

Future Work

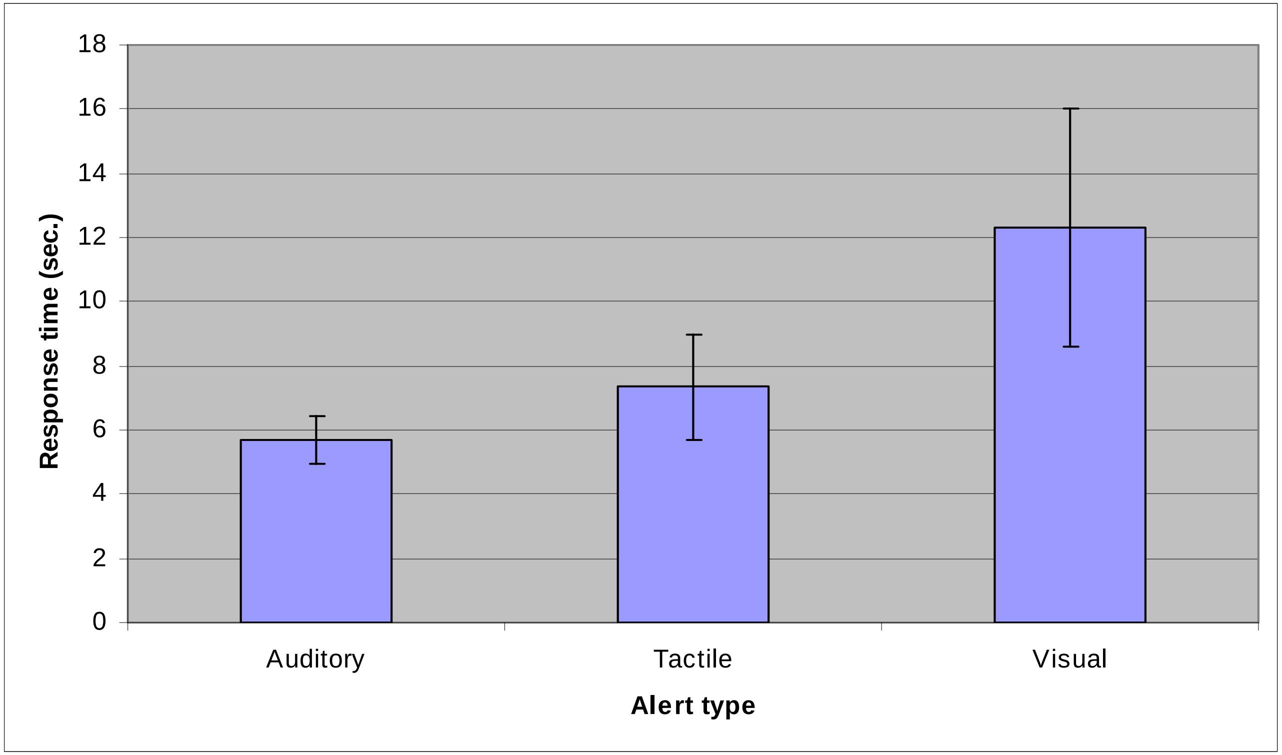
- Effects of vehicle vibration on detection of tactile cues.
  - Summer 06
- Effects of alert urgency on decision making and performance
  - Spring 06

Extra Slides

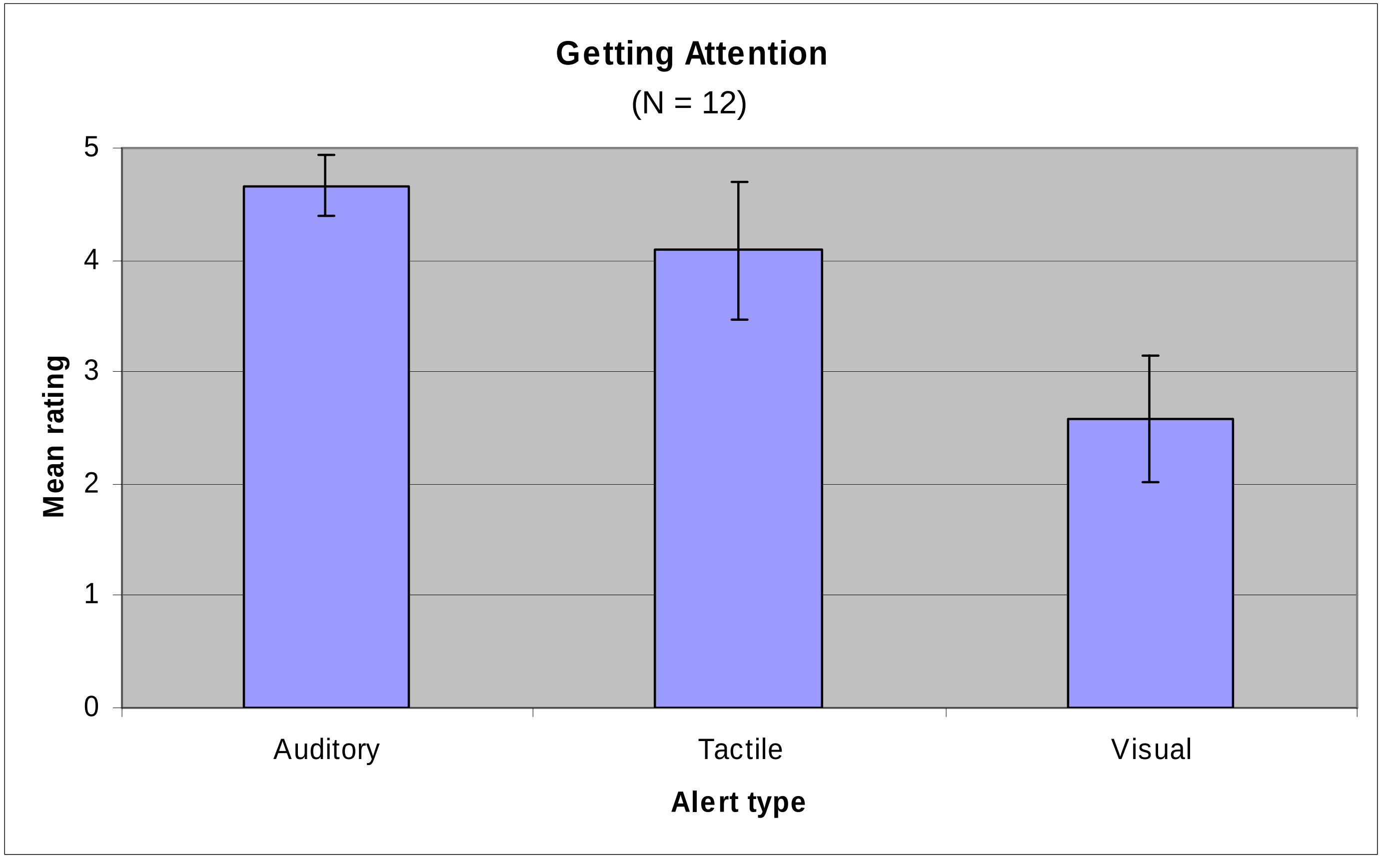
Response Time

Human Research and Engineering Directorate

- Visual alert
  - 54% slower than auditory
  - 41% slower than tactile



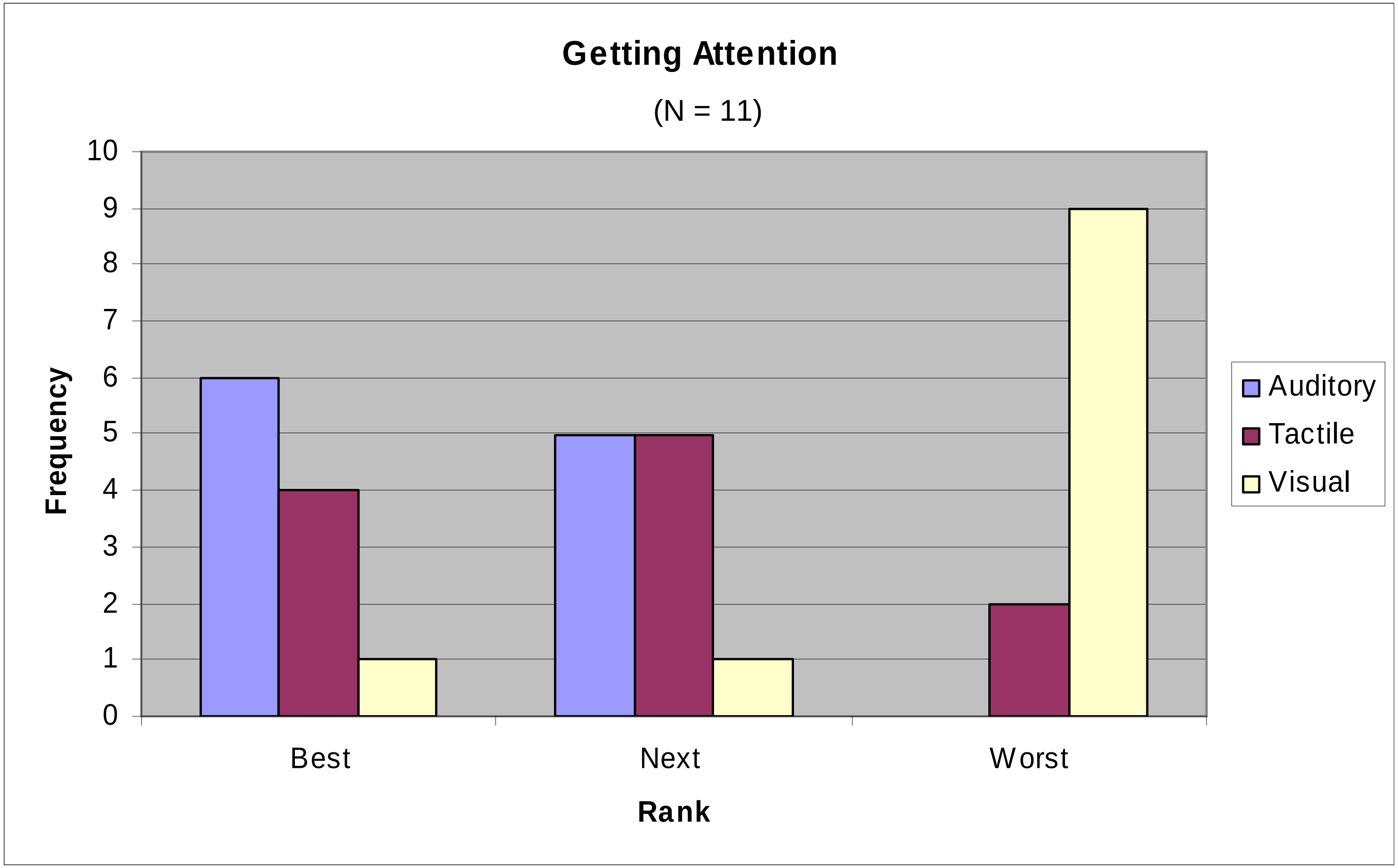
Subjective Ratings



(1) Strongly Agree	(2) Agree	(3) Neither agree nor disagree	(4) Disagree	(5) Strongly Disagree

Subjective Rankings

Human Research and Engineering Directorate



Subjective Rankings